THE NICKEL BULLETIN

A MONTHLY SUMMARY OF CURRENT INFORMATION

MAY, 1957

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ABSTRACTS OF CURRENT PUBLISHED INFORMATION ON NICKEL AND ITS ALLOYS

GENERAL

Phase Transformations in Metals and Alloys

INST. METALS: 'The Mechanism of Phase Transformations in Metals.'

Inst. Metals Monograph and Report Series No. 18. Published by the Institute 1956; 346 pp. Price 50/-.

The monograph contains the series of papers and the discussion presented at a symposium organized by the Institute in November, 1955. The material is divided into two parts, the first dealing with nucleation and growth processes, the second with martensitic transformations. Each part is introduced by a comprehensive review of major aspects which are to be considered in the section and the review papers are followed by shorter contributions reporting original work in the various relevant fields of interest. These latter papers include reports of research carried out in the U.K., in various centres on the Continent of Europe, and in the U.S.A. Together they form a valuable summary of the present state of knowledge on the subject.

Preparation of Catalysts: Influence on Performance

See abstract below.

The Salt-Spray Test

See abstract on p. 73.

NICKEL

Preparation of Catalysts: Influence on Performance

'Preparing Catalysts in the Laboratory.'

Industrial and Engineering Chemistry, 1957, vol. 49, Feb., pp. 240–87.

The spectacular expansion of the chemical and petroleum-processing industries during the past few years has been due in no small measure to developments in catalytic processes. In consequence, the manufacture of catalytic materials has become an increasingly important side of chemical industry.

Although much scientific study has been devoted to the mechanism of catalytic action and correlation of the influence of the many variables which enter into catalysis, the search for new and improved catalyst substances has been mainly along empirical lines. It is being increasingly realized, however, that chemical composition is not the only factor determining catalyst activity and adequacy: conditions at the surface of the catalyst, crystal structure, surface area, pore size and structure, particle size, degree of dispersion, and possibly other properties, influence the activity, selectivity, life and other attributes of catalysts. These variables are determined to a large extent by the mode of preparation of the catalyst. The aim of the papers presented in this symposium is to elucidate the influence of some of the variable conditions which may occur in preparation: the scope of the papers is indicated below. In addition to those relating specifically to nickel-containing catalysts, data included in several other reports are directly relevant to such materials.

Scope of Contributions to Symposium

Basic principles and standard techniques for laboratory preparation of catalysts.

Pre-formed catalysts and the technique of production of tableted catalyst.

Effects of methods of preparation on the properties of nickel-oxide polymerization catalysts.

Adsorption and exclusion effects in the impregnation of porous catalyst supports.

Radiation quenching, ion bombardment and annealing of nickel and platinum for ethylene hydrogenation.

Effect of HF on the acidity of alumina.

Catalytic properties of rare earths.

Carbon monoxide/steam reaction on ruthenium catalysts.

Fluid-cracking catalyst contamination.

Gas-oil cracking by silica-alumina bead catalysts.

Calcium/Nickel-Phosphate Catalyst

'Esso to Use Dow Catalyst.'

Chemical and Engineering News, 1957, vol. 35, Feb. 18, p. 22.

It is noted that Esso Research and Engineering in U.S.A. is now licensed to use the Dow Type B calcium/nickel-phosphate catalyst and process for production of butadiene by dehydrogenation of butylene petroleum fractions. Esso Petroleum Limited will also employ the same process at their Fawley Refinery in the U.K.

For details of the development of this catalyst, see papers referred to in *Nickel Bulletin* 1955, vol. 28, No. 11, p. 180.

Wrought Nickel: Data Sheet

See abstract on p. 74.

Magnetostrictive Properties of Nickel-containing Materials and their Application

E. M. WISE: 'Magnetostriction: A New Design Tool.'

Product Engineering, 1957, vol. 28, Jan., pp. 162–6.

Reprint issued by *International Nickel Co., Inc.*

The practical applications of magnetostriction

(change of dimensions of a ferromagnetic material under the influence of a magnetic field) were considerably stimulated by developments during World War II. Among the uses then developed were Sonar and related devices for detection of submarines and ships by pulse generation and reflection. Success in such applications has resulted in much interest in the potential value of magnetostrictive effects as a means of regulating industrial processes, e.g., feed mechanisms for machine tools, welding by vibratory energy introduced from a transducer (giving a solid-state metallurgical bond, with low deformation and no fusion), and cleaning processes, in which cavitation produced in the fluid medium results in more thorough cleaning of complex shapes.

The most important materials in connexion with magnetostrictive devices are nickel, cobalt and certain alloys containing those metals. This article includes graphs illustrating the characteristics of the two metals and of a number of nickel-iron alloys, demonstrating the effects of composition of the metal or alloy which forms the core material of the transducers, the influence of dynamic strain on performance, and the significance of mechanical and magnetic hysteresis losses and eddy-current losses, as affecting the permissible operating level of magnetostrictive devices. Transducer design in relation to performance is also considered.

Spectrophotometric Determination of Nickel

Y. UZUMASA and S. WASHIZUKA: 'Ultra-Violet Spectrophotometric Determination of Nickel with Benzil α-Dioxime.'

Bull. Chemical Soc. Japan, 1956, vol. 29, pp. 403–7 (in English). *Analytical Abstracts*, 1957, vol. 4, Feb., Abs. No. 519.

The authors describe a precise method for estimating microgram quantities of nickel: the procedure is claimed to be virtually free from interference by elements other than cobalt. The nickel is extracted as the benzil α-dioxime complex with $CHCl_3$, the solution is treated with alkali and the extinction is measured at 275μ. Details of procedure are given in the abstract.

ELECTRODEPOSITION AND OTHER COATING METHODS

Electrodeposition of Metals: Institute of Metal Finishing Conference

Papers presented at the Spring Conference of the Institute of Metal Finishing, held in April, covered subjects of outstanding interest in the finishing of metals with both inorganic and organic coatings. The scope of the papers is shown in the abstracts.

I. ELECTRODEPOSITION AND RELATED SUBJECTS

S. A. WATSON and J. D. EDWARDS: 'An Investigation of the Mechanism of Levelling in Electrodeposition.' *Advance Copy No.* 1; 33 pp.

Levelling power, defined as a function of the deposit thickness obtained at the peaks and recesses of a standard rough surface, was measured for nickel-plating solutions of various types, for an iron-zinc solution and for a nickel-phosphorus solution. The work included a study of the effects, on levelling power and cathode potential, of variations in current density and in the concentration of a variety of addition agents. Most of the experimental work was carried out on pieces of long-playing gramophone-record master electroformed in copper, having either 50μ (0·002 in.) deep grooves with a centre-to-centre inter-groove distance of 125μ (0·005 in.) or grooves 20μ (0·0008 in.) deep with a separation of 100μ (0·004 in.). The relatively large irregularities on such surfaces made possible quantitative expression of levelling action and also facilitated examination of the distribution of incorporated matter, but since levelling is of greater practical importance on surfaces of finer roughness, some measurements were made also on surfaces finely ruled with a diamond. In these cases the shallow grooves on the surface were approximately 0·1μ (0·000004 in.) deep and 1μ (0·00004 in.) wide.

The report embodies full details of the methods employed for measuring the cathode efficiency, levelling power, cathode potential and distribution of the matter incorporated in the deposits, and an extensive account is given of the respective experiments in which the influence of variables in composition of the electrolytes and operating techniques was studied. Such operating variables included current density and agitation of the solution.

The results are discussed in the light of a hypothesis which is advanced as accounting satisfactorily for the main features of levelling action demonstrated in the experiments. It is assumed that all levelling solutions contain a minor constituent which is incorporated in the electrodeposit, either by co-deposition or adsorption, and that this lowers the cathode potential to an extent dependent upon its concentration in the surface of the deposit. The continuous incorporation of this constituent in the deposit reduces its concentration near the cathode surface and leads to the establishment of a concentration gradient in the cathode layer, i.e., the layer of electrolyte adjacent to the cathode. On a rough surface the rate of arrival, at the cathode, of diffusing ions or molecules is greater on projections than in hollows, resulting in a higher rate of incorporation of particles of addition agent and a greater decrease in cathode potential on projecting parts of the surface. Current is therefore diverted into the hollows and a levelled deposit results. The support given to this hypothesis by the experimental data is concisely summarized and an equation is derived permitting calculation of levelling power in terms of current density, concentration of addition agent and the rates of change of cathode potential with these

two factors. Plots of calculated levelling power against concentration for coumarin, thiourea and saccharin show many points of resemblance to the corresponding experimental curves.

Attention is drawn to practical implications which arise from the mechanism of levelling proposed:

Under suitable conditions, substances which, when added to an electroplating solution, are incorporated in the deposit and lower the cathode potential, i.e., make it more negative, should behave as levelling agents. If a single addition agent is used the levelling power of the solution is critically dependent on concentration of the addition agent, and this should be carefully controlled.

It is possible to calculate approximately, from known relationships between cathode potential, levelling-agent concentration and current density how levelling power will vary with changes in plating conditions.

In connexion with choice of concentration of the levelling agent, it is noted that current density frequently varies widely over articles which are being plated: it is therefore probably advisable to use a concentration of addition agent which would give maximum levelling power at a current density lower than that at which the solution is to be used, thus ensuring good levelling at positions at which the plating is thinnest. On shaped articles it is possible that the use of more than one levelling agent would give best all-over levelling, but the feasibility of this suggestion is subject to further research.

Agitation of the solution would be expected to have little effect on the maximum levelling power attainable, but would probably be necessary in most cases in order to maintain adequate circulation and to prevent plating defects. Factors which increase the slope of the polarization/current-density curve, e.g., complexing of the principal metal ions, tend to make the current density more uniform and therefore, although they increase throwing power, would decrease levelling power. Increase in the conductivity of the electrolyte would increase levelling power as well as throwing power, but the effect on levelling power would be relatively small.

Levelling power increases as the scale of roughness decreases, but the effect becomes progressively smaller. There is no theoretical limit to the levelling action which can be attained.

(The authors draw attention to two papers which have been published since their own report was written, viz., those by FOULKE and KARDOS and by KARDOS, reported in the *43rd Annual Technical Proceedings of the American Electroplaters' Society*, pp. 172 and 181; see *Nickel Bulletin*, 1957, vol. 30, No. 4, p. 52. The American investigators, employing a different approach, propose a mechanism of levelling practically identical with that suggested by the present authors.)

A. HICKLING and H. P. ROTHBAUM: 'Cyclic Electrolysis: Part II. The Influence of Periodic Reversal of Current upon the Surface Roughness of Electrodeposited Copper.'

Advance Copy No. 2; 24 pp.

The work reported was undertaken with a view to discovering the mechanism by which periodic reversal (P.R.) of current can in some cases restrain the development of roughness in electrodeposited metals. Since the patent literature suggests that the greatest influence of P.R. is found in deposition of copper, particularly from cyanide solutions, that metal was selected for these investigations. A study was made of the effect of P.R. on the rate of roughening of copper deposited from cyanide, sulphate and phosphate baths, under simplified plating conditions.

G. H. JENNER and T. P. HOAR: 'Peen Plating.'

Advance Copy No. 4; 18 pp.

Peen plating is a newly developed method for plating hardware with such metals as zinc and brass, without the use of heat or electricity. The process comprises a combination of the technique of barrel finishing with the principle of cold welding. Plating is carried out in a modified tumbling barrel, containing the coating metal in the form of powder and also the impacting material. The operation is done under water, to which chemical substances are added to promote the cold welding of the powder to the basis metal. This paper describes equipment, materials and the process, with consideration of the scope of its application. Articles suitable for peen plating include tacks and nails, clamps and washers, small fasteners, hooks, springs, and small stampings of many kinds. The trademark 'Peneplate' has been registered.

A. M. HARPER, A. MOHAN and S. C. BRITTON: 'Electrodeposition of Tin as a Bright Coating.'

Advance Copy No. 5; 18 pp.

Bright ductile deposits of tin have been obtained from acid stannous-sulphate solutions to which wood tar dispersed in aqueous solution has been added. The dispersing agent used was octyl sulphuric acid, but it is noted that some alternative media may be employed. Promising results have also been obtained by the addition of the tar preparation to chloride/fluoride tin-plating baths.

R. PIONTELLI and G. SERRAVALLE: 'A Contribution to Knowledge of the Cathode Polarization Phenomena of Nickel.' *Advance Copy No.* 6; 18 pp.

The authors point out that information relating to the cathodic polarization behaviour of nickel is at present inadequate, both from the theoretical aspect and because the data available are limited to effects observed only in sulphate and chloride solutions, in particular conditions.

This paper supplements the relevant information by a report of research on nickel, carried out in a wide range of conditions and in less commonly used solutions, such as sulphamate, perchlorate and fluoborate types. The special cell devised by the authors for examination of the cathodic behaviour of metals is described and illustrated.

The results of their experiments are discussed in relation to other associated work which has already been published by them or is in preparation, and in the light of the literature from other sources.

A condensed critical review is made of the theories which have been advanced to interpret the electrochemical inertia of nickel and the authors confirm their belief in the validity of a theory which they have previously put forward, involving consideration of four factors:

(1) the bonding of nickel ions, both in the lattice and in solution,

(2) the direct rôle of the anions in the ionic transfer medium,

(3) the possible passivation of the metal surface, by adsorption,

(4) the conditions of formation and the electrical and electrochemical properties of the finally deposited layers.

It is emphasized that the very important influence exerted by the anions, demonstrated in this and other papers, has been discussed by various investigators, and reference is made here to the explanatory theories which have been advanced. In the case of nickel the nature of the anion is important also as influencing the conditions of formation of basic colloidal compounds in the cathode layer, and affecting also their properties and their occlusion in the deposits.

C. WILLIAMS and R. A. F. HAMMOND: 'The Change of Fatigue Limit on Chromium or Nickel Plating, with Particular Reference to the Strength of the Steel Base.'

Advance Copy No. 7; 33 pp.

In a previous investigation* the authors had established that in a particular type of steel (2½ per cent. nickel - chromium - molybdenum steel to En 25 specification), in two conditions of heat-treatment, the fatigue limit, after chromium plating, was independent of the ultimate tensile strength of the steel over the range 60–80 tons per sq. in., although the percentage loss of fatigue strength was higher for the harder steel. It was also established that the fatigue strength of steel after chromium plating was determined by (*a*) the magnitude and the sign of the internal stress present in the chromium deposit and (*b*) by the intrinsic fatigue strength of the chromium coating. It was tentatively concluded that the intrinsic fatigue limit of conventional chromium deposits is 20–25 tons per sq. in. for heat-treated coatings and about 28 tons per sq. in. for as-plated deposits. It therefore appeared probable that with relatively strong steels fatigue failure is initiated in the chromium deposit and that the fatigue limit of the plated component is thus limited by the intrinsic fatigue strength of the chromium. (Confirmation of this conclusion is afforded by a paper by Stareck et al.; *Plating*, 1955, vol. 41, p. 1395.)

These results appeared to indicate that, in contrast to the behaviour of medium- and high-tensile steels, the fatigue limit of low-strength materials might be increased by chromium plating. The work reported in the present paper was carried out to test the validity of this assumption and to check the accuracy of the previous conclusions by using steels of different composition and having wider tensile-strength ranges. The basis materials used varied from Armco iron (carbon 0·02 per cent.) to steels containing 0·5 per cent. of carbon, and an 18-8 chromium-nickel steel.

The results of the authors' tests, considered in conjunction with other published information, indicate certain fairly clear-cut relations between the fatigue strength of unplated and plated steel. The main conclusions drawn are given below.

When a steel is chromium plated there is a linear relationship between the percentage change in fatigue strength and the fatigue limit of the steel. Arising from this relationship, it is possible, in unbaked deposits of a known level of internal stress, to predict the percentage change in fatigue strength resulting from chromium plating, provided that the fatigue limit, the tensile strength, or the D.P.H. value of the steel is known. This deduction is possible, irrespective of the composition of the steel. A formula is derived for such calculation.

For very soft steels the fatigue strength may be increased by chromium plating, and there is evidence that failure is initiated in the steel at the steel/plating interface. For conventional chromium plating having an internal stress of the order of 4 tons per sq. in. this condition applies for steel having, unplated, a fatigue limit of 18 tons per sq. in. or less. For steels of a strength above that level the chromium plating first fails when the applied stress plus the internal stress reaches the inherent fatigue limit of the chromium (20–22 tons per sq. in.). Propagation of the crack in the chromium, into the steel, and consequent failure of the component, appear to occur only when the stress concentration at the root of the crack approaches the fatigue limit of the substrate.

The authors' investigations on the influence of nickel plating were made on coatings electrodeposited from two dull and three bright solutions. The results of these experiments, together with other data previously available, are considered to offer definite evidence that the general effects which have been observed for chromium coatings may apply also to nickel plating. It is believed that, for certain types of nickel deposit, the linear relationship between the percentage change of fatigue limit and the fatigue limit of the steel base is valid. As in the case of chromium, there appears to be a linear relation between the internal stress present in the nickel deposit and the percentage change in fatigue strength of the plated composite. In contrast to unbaked chromium deposits, the percentage loss of fatigue strength increases with the thickness of some nickel coatings.

T. P. HOAR and D. J. ARROWSMITH: 'An Instrument for the Continuous Measurement of Stress in Electrodeposits.'

Advance Copy No. 8; 10 pp.

Following a brief summary of the literature dealing with methods which have been proposed for measurement of stress in electrodeposited coatings, the authors

**Trans. Inst. Metal Finishing*, 1955, vol. 32, pp. 85-106; *Nickel Bulletin*, 1955, vol. 28, Nos. 6-7, p. 102.

describe a new type of instrument which is free from some of the disadvantages inherent in methods involving bending of the specimen. According to the new technique, metal is deposited on one side of a thin metallic strip fixed at the bottom, and to the top of the strip there is attached a light armature of soft iron. The stress present in the deposit is determined by measuring the current through a solenoid which provides, on the armature, a restoring force sufficient to prevent the strip from bending. The relation between restoring force and stress is derived.

The use of the instrument is demonstrated by description of tests on nickel coatings electrodeposited from solutions basically of the Watts type, and modified with various stress-relieving and brightening agents.

H. SILMAN and J. E. ENTWISTLE: 'The Cleaning of Intricate Parts.'
Advance Copy No. 15; 14 pp.

Recent developments in cleaning techniques and plant are described. These include automatic vapour and liquid-solvent degreasing machines, also emulsion cleaners, and some special machines which have been designed for their effective application. Particular attention is directed to ultrasonic cleaning, as being the most important recent development in methods of removing soil from intricate parts. Ultrasonic cleaning plant consists essentially of a tunable ultrasonic oscillator, a power amplifier, a transducer for conversion of electrical energy into acoustic or mechanical energy, and a container of glass or stainless steel, in which the articles are immersed in the cleaning medium. The solvents used are generally chlorinated hydrocarbons, which are particularly suitable on account of their dielectric properties. Aqueous solutions can in some cases be employed.

The authors describe the transducers used, making reference to the type which utilizes piezoelectric crystals and to those in which magnetostrictive material (usually nickel or nickel alloys) are used as the means of converting electrical energy into sound or mechanical force. The nature of the cavitation effect produced in the cleaning medium is discussed, with consideration of operating conditions which influence its intensity. The use of ultrasonic cleaning is described as exemplified in the treatment of automobile brake components and watch parts.

J. W. CUTHBERTSON and J. E. PARTON: 'Possibilities of Automatic Control in the Electroplating Industry.'
Advance Copy No. 16; 15 pp.

The paper reviews the types of industrial automatic control already available in this industry, the requirements of which are discussed in detail. It is pointed out that satisfactory methods exist for control of temperature and agitation of electrolytes, but that regulation of current density, composition of electrolyte and electrode geometry is more difficult. It is suggested that integral multi-loop control may be an ultimate solution for overall control.

II. ORGANIC COATINGS

W. D. MAY, N. D. P. SMITH and C. I. SNOW: 'The Adhesion of Surface Coatings.'
Advance Copy No. 9; 14 pp.

Methods currently used for measurement of the adhesion of organic coatings are critically reviewed. A new method is described in which the coating is detached from its substrate by the rapid deceleration obtained when the specimen is fired from a compressed-air gun at a hardened steel target.

A. L. NEWCOMB: 'Advances in Spray Booth and Oven Designs.'
Advance Copy No. 10; 10 pp.

The paper reviews some recent developments in America.

J. MUIRHEAD: 'The Application of Finishing Materials at Controlled Temperatures.'
Advance Copy No. 11; 6 pp.

A general consideration of the advantages of using controlled (elevated)-temperature application of paints or other organic coatings. Some of the factors involved in using materials of high solids content are discussed.

T. COWLAND: 'Airless Spray.'
Advance Copy No. 12; 7 pp.

The Airless Spray System is a method recently developed for the application of paints and other organic coatings. The limitations (operative, hygienic and economic) of conventional methods of compressed-air spraying are briefly noted and the new method is described, as offering means for overcoming these disadvantages.

J. WEBB: 'Automatic Spraying.'
Advance Copy No. 13; 10 pp.

Description of five different types of automatic paint-spraying machines.

E. E. V. SHARPE: 'Aerosol Spraying.'
Advance Copy No. 14; 8 pp.

A paint aerosol is essentially a self-contained paint supply together with its means of application. The propellant gas, which inside the aerosol is freely mixed in fluid form with the paint, provides both the means of atomization and of particle propulsion. The scope and potential usefulness of paint aerosols is considered, with special reference to their advantage for small-scale use. Recommendations are made with regard to correct technique of application.

III. ANODIZING

A. W. BRACE and R. PEEK: 'Production and Properties of Opaque Coatings by Chromic-Acid Anodizing.
Advance Copy No. 3; 18 pp.

It has been established that attractive opaque coatings can be produced by anodizing in a 10 per cent. CrO_3 electrolyte at 130°F. (55°C.) and 30 volts. Films so produced can be dyed to give an enamel-like appearance, and they are found to have better

resistance to corrosion than sulphuric-acid anodized films of equivalent thickness. An outstanding property claimed is the ductility of the films produced from the chromic-acid electrolyte.

Effect of Calcium in Nickel-Plating Solutions

A. J. SMITH and R. BACON: 'Effects of Impurities and Purification of Electroplating Solutions. 1. Nickel Solutions; 2. The Effect and Removal of Calcium.'

Plating, 1957, vol. 44, Feb., pp. 186–7.

Report issued under the aegis of A.E.S. Research Project No. 5.

Calcium present in the water used for making up plating solutions is one of the most common impurities in electrolytes: the normal calcium content is considered to be not less than 30 p.p.m. The consensus of opinion has been that the calcium ion is relatively harmless and there has been little study of its effect in plating.

In the investigation reported, calcium was added in amounts above the normal limits, using as basis solutions the types employed in other sections of the research on the influence of impurities: Watts solutions of 2·2 and 5·2 pH, an organic bright solution and a nickel-cobalt solution. The calcium additions made to each electrolyte were 350 and 700 p.p.m. (the limit of solubility in the Watts pH 5·2 solution), and the deposits produced were compared with those made from similar solutions containing only the normal amount of calcium, i.e., 'pure' solutions. The calcium was added as calcium carbonate and the pH was adjusted to the desired level. As with the other impurities investigated, the influence of calcium was studied as affecting the throwing power of the electrolyte and the appearance, ductility, hardness, adhesion and corrosion-resistance* of the deposits.

It was found that calcium, in the amounts used, was without effect on any of the properties studied. In view of the position of calcium in the electrochemical series, these results were to be expected, since it was not to be anticipated that calcium would plate out with the nickel. Spectrographic analyses on stripped deposits revealed no entrapped calcium.

No method was found for removal of calcium from the solutions. Both low-current-density electrolysis and high-pH precipitation were completely ineffective. It would appear that in hard-water areas there may be a steady build-up of dissolved calcium, which may in time exceed the solubility limit. The only way to overcome the problem appears to be dilution of the calcium content by addition of purified water to the electrolyte.

Plating of Nickel Wire

O. E. ADLER: 'Wire Plated before Drawing by Novel Spiral Process.'

Wire and Wire Products, 1957, vol. 32, Feb., pp. 168–9, 217.

The article describes some features of the improved Kenmore process for pre-plating of wire with nickel before drawing and coiling. The process used is that formerly known as Fernicklon and the trade name of Nickelply has been chosen for the plated product.

The basis metal used may be alloy steel or copper alloy. It is claimed that the ductility of the deposited coating is such that very large reductions can be effected in the course of drawing of wire to size, and that adhesion and quality of the coating remains satisfactory under the drastic forming operations involved in fabrication. Applications of the plated wire include a variety of electrical and electronic parts and other components in which a combination of strength, corrosion-resistance and lustrous finish is desired. Lamp-frame wire, wire-conveyor belting, coat hangers and many items of domestic hardware are further examples of the uses for which the coated wire may be employed.

The Salt-Spray Test

A. MENDIZZA: 'The Standard Salt-Spray Test—Is It a Valid Acceptance Test ?'

Plating, 1957, vol. 44, Feb., pp. 166–71; disc., pp. 171–5.

Notwithstanding its widespread use, the salt-spray test is much criticized as being unrealistic in relation to service performance. (Reference is given in this paper to some of the main critical literature.)

As a means of evaluating the usefulness of the test as a specification requirement, the American Society for Testing Materials recently conducted an investigation with the object of establishing the degree to which the salt-spray test could be regarded as reliable and reproducible. The main objectives of the investigation were (1) to determine the relationship between salt-spray resistance and thickness of the coating, and (2) to ascertain the degree of reproducibility of test data for coatings prepared, by several producers, to the same thickness requirements and tested by a number of laboratories in conditions conforming to A.S.T.M. Method B-117. The main conclusions drawn are summarized in the *Proceedings of the American Society for Testing Materials*, 1954, vol. 54, pp. 299–310.

In the present report, the data obtained in those tests are presented graphically and some statistical analysis is made of the results. The test specimens used comprised six sets of panels representing various types of coating on two grades of steel:

A. 0·0015 in. nickel, on N.A.X.* steel.

B. Copper flash +0·0015 in. nickel, on N.A.X. steel.

C. 0·0009 in. copper + 0·0006 in. nickel, on N.A.X. steel.

D. 0·00125 in. nickel, on N.A.X. steel.

E. 0·00125 in. nickel, on S.A.E. 1010 steel, and

F. 0·00075 in. nickel, on S.A.E. 1010 steel.

A final coating of chromium, 0·00002 in. thick, was superimposed in all cases.

The specimens were examined in four separate laboratories in conditions conforming with the

*Tested by the acetic-acid/sodium-chloride salt-spray method.

*A low-chromium steel of high tensile strength.

A.S.T.M. specification. Rust-spot counts were made after every 24-hour period and the tests were run for varying periods, depending on the thickness of coating.

The results recorded confirm the opinion which is already widely held that the salt-spray test procedure, as currently practised, fails to satisfy the requirements of a standard test. It is concluded that an accelerated corrosion test must, in order to be acceptable as a standard, comply with certain minimum conditions, among which the more important are:

(1) Uniformity of conditions must exist in all test cabinets.
(2) Standard samples should be provided for calibrating the test cabinets.
(3) Standards should be included in all test runs.
(4) A continual check should be maintained on the behaviour of the cabinet, to ascertain that no irregularities occur.

The general trend of the discussion on this report was to emphasize general dissatisfaction with the salt-spray method, and to urge the need for developing a more reliable corrosion-test procedure which would give information in closer agreement with observed service behaviour.

Properties of Electrodeposited Nickel-Alloy Coatings at High Temperatures

See abstract on p. 78.

Nickel-Plated Fourdrinier Wires

See abstract on p. 81.

NON-FERROUS ALLOYS

Wrought Nickel and Nickel Alloys: Data Sheet

Materials and Methods, 1957, vol. 45, Feb., pp. 143, 145.

Tabulated summary of typical physical and mechanical properties, fabricating characteristics and available forms of the materials listed below. Thermal treatments suitable for the respective types are also given and the scope of use of the materials is broadly indicated.

Nickel Silvers: Data Sheet

J. L. EVERHART: 'Nickel Silvers.'
Reprint of *Materials and Methods Manual No.* 133, Dec., 1956; 16 pp.
Issued by INTERNATIONAL NICKEL CO., INC.

For abstract see *Nickel Bulletin*, 1957, vol. 30, No. 3, p. 38.

Copper and Copper Alloys: Literature Review

E. VOCE: 'Copper and Copper Alloys: A Survey of Technical Progress during 1956.'
Metallurgia, 1957, vol. 55, Mar., pp. 109–20.

Closely documented review of the literature of late 1955 and of 1956. The information is classified in sections relating respectively to production of copper, foundry practice, fabrication, finishing and plating, properties and applications, corrosion, joining, physical metallurgy, and inspection, testing and analysis.

The supporting *bibliography* comprises 276 items.

Production of Nickel-Aluminium Bronze Propellers by the CO_2 Process

R. H. HERRMANN: 'Making Ship Propellers with CO_2 Molds and Cores.'
Foundry, 1957, vol. 85, Feb., pp. 104–9.

The article describes the technique used in the Brooklyn Foundry of Columbian Bronze Corporation, Freeport, where the CO_2 process has been in large-scale use for about a year. The benefits which accrue from the use of this process include much increased fidelity of the castings to pattern dimensions, saving on moulding time, and all-over economy in production costs. The main output of the foundry is ships' propellers in manganese bronze and nickel-aluminium bronze (copper 80, aluminium 10·5, nickel 5, iron 4, manganese 0·5, per cent.). Some aluminium castings are also made.

	Ni %	C %	Mn %	Fe %	S %	Ti %	Si %	Cu %	Cr %	Nb +Ta %	Al %
'A' Nickel	99·45	0·06	0·25	0·15	0·005	—	0·05	0·05	—	—	—
Low-Carbon Nickel	99·55	0·01	0·20	0·15	0·005	—	0·05	0·05	—	—	—
Duranickel	93·90	0·15	0·25	0·15	0·005	0·45	0·55	0·05	—	—	4·05
Monel	66·0	0·12	0·90	1·35	0·005	—	0·15	31·50	—	—	—
'K' Monel	65·30	0·15	0·60	1·00	0·005	0·50	0·15	29·50	—	—	2·80
Inconel	76·40	0·04	0·20	7·20	0·007	—	0·20	0·10	15·85	—	—
Inconel 'X'	72·80	0·04	0·70	6·75	0·007	2·55	0·30	0·05	15·15	0·85	0·80

Properties of Ferrous and Non-Ferrous Casting Materials

E. KNIPP: 'Materials for Metal Castings.'
Published by *Giesserei-Verlag G.m.b.H., Düsseldorf*, 1956; 173 pp.

Reference book for engineers interested in ascertaining the suitability of various casting materials for specific applications. The information, which is presented in tabular form, covers compositions, physical and mechanical properties, casting characteristics and working properties of materials which can be used in cast form. Attention is drawn also to outstanding qualities such as corrosion-resistance, wear-resistance, etc., and a broad indication is given of the uses of the respective materials. Some comparison is made of the production costs in relation to cost of grey cast iron. The materials for which data are tabulated include many forms of plain and alloy cast iron, and malleable cast iron; cast steels of unalloyed and low- and high-alloy types; copper-, zinc-, and lead-base a loys; nickel silvers and nickel-containing bronzes; nickel-chromium, nickel-chromium-iron, nickel-molybdenum, nickel-silicon and nickel-cobalt-copper alloys, and aluminium- and magnesium-base alloys.

The values given are based on D.I.N. standard specifications and on published literature, producers' catalogues and unpublished communications received by the author, supplemented by his own records.

Nickel Selenides

F. GRONVOLD and E. JACOBSEN: 'X-Ray and Magnetic Study of Nickel Selenides in the Range NiSe to $NiSe_2$.'
Acta Chemica Scandinavica, 1956, vol. 10, No. 9, pp. 1440-54.

The authors make an introductory survey of major literature since the discovery, in 1859, of a nickel selenide having a composition close to NiSe. In view of the many nickel selenides which have been described, a systematic study of the nickel-selenium system was started in 1950 in the Chemical Institute of the University of Oslo. One section of the investigation is concerned with the nickel-rich region of the system; the other, which is reported in the present paper, deals with the selenium-rich area covering the NiSe-$NiSe_2$ region.

NICKEL-IRON ALLOYS

Ferromagnetic Resonance in Nickel-Iron Alloy Films

P. E. TANNENWALD and M. H. SEAVEY: 'Ferromagnetic Resonance in Thin Films of Permalloy.'
Physical Rev., 1957, vol. 105, Jan. 15, pp. 377-8.

Microwave resonance measurements were made in evaporated 82-18 nickel-iron alloy films of thicknesses varying from 760 Å to 1600 Å.

Magnetostrictive Properties of Nickel-containing Materials

See abstract on p. 68.

CAST IRON

Desulphurization of Cast Iron

'Desulphurization of Cast Iron: Selected References, excluding Patents.'
Bull. Brit. Cast Iron Research Assocn., 1956, vol. 13, Sept., pp. 454-66.

In the past few years, desulphurization of cast iron has assumed increasing importance, and the attention of foundrymen has been directed towards the desirability of making lower-sulphur cast iron, for three principal reasons:

(*a*) The sulphur content of coke tends to rise, and this is reflected in increased sulphur contents in cast iron.

(*b*) The advent of S.G. iron has caused a demand for low-sulphur cast iron.

(*c*) Recent work on the occurrence of certain foundry defects in cast iron has drawn attention to the undesirability of high sulphur contents.

This classified *bibliography*, prepared by the British Cast Iron Research Association, is designed to provide some essential information on the theory and practice of desulphurization.

The first section contains papers relating to the chemistry and physics of sulphur in iron and its removal, the second refers to general articles on desulphurization, and the third to specific processes.

The *bibliography* contains 74 items of technical literature.

Risers for Use in Production of S.G. Iron

H. F. BISHOP and C. G. ACKERLIND: 'Dimensioning of Risers for Nodular Iron Castings.'
Foundry, 1956, vol. 84, Dec., pp. 115-19.

The authors describe a system for determining the minimum sizes of riser required to prevent shrinkage in S.G. iron castings. The work is an extension of research on risers for steel castings, and it has been found that the system described earlier is applicable also to S.G. iron.

The subject is discussed at considerable length, with explanatory diagrams. Two features which emerge from this work are of considerable importance:

(1) the relationship between the riser volume and the carbon equivalent of S.G. iron,

(2) the relative importance of the diameter of a riser, as compared with that of its height.

Influence of Grain Size on Mechanical Properties of S.G. Iron

G. N. J. GILBERT: 'The Effect of Grain Size on the Mechanical Properties of Ferritic Nodular Irons.'
Brit. Cast Iron Research Assocn., Jnl. of Research and Development, 1956, vol. 6, Dec., pp. 430-5; *B.C.I.R.A. Research Report No.* 449.

The results reported show that improved tensile and impact properties are associated with a fine ferrite grain size. The improvement in tensile properties is indicated by a substantial increase in proof stress and lowering of the impact-transition temperature.

Impact Properties of Ferritic S.G. Iron

G. N. J. GILBERT: 'The Impact Properties of Ferritic Nodular Irons in the Ductile and Brittle Condition, using Standard and B.C.I.R.A. Impact Specimens.'
Brit. Cast Iron Research Assocn., Jnl. of Research and Development, 1956, vol. 6, Dec., pp. 422–9; *B.C.I.R.A. Research Report No.* 448.

The report covers the examination of various cast irons tested in impact, using the 0·798-in. diameter un-notched bar, the standard Charpy and Izod bars and, for comparison, special bars designed by the British Cast Iron Research Association.

The results show that the 0·798-in. bar, devised initially for testing flake-graphite irons, is unsuitable for use on S.G. iron, even in a relatively brittle condition. The other bars all gave results leading to a similar form of transition curve.

The similarity of results given by the standard 10-mm. square beam specimens for the Charpy test and the 10-mm. square and 0·45-in. diameter round Izod specimens is significant in connexion with the inclusion of all these forms of test as alternatives in the new British Standard specification.

S.G. Iron in Reel Spiders

'Ductile Iron in Reel Spiders.'
Jnl. Franklin Inst., 1956, vol. 262, Nov., p. 421.

This note refers to the successful use of S.G. iron for spiders on a steel shaft forming the main support for screens used for grading cereals. The spiders carry the wrought steel lift arms of the stainless-steel grading screen, together with the load of the grain during the grading operations. A tough, shock-resistant material is required for such service and grey cast iron spiders had proved inadequate. S.G. iron is, however, reported to be giving complete satisfaction. During installation of some spiders in a grader located high in a grain elevator, one of them was accidentally dropped from a height of 160 ft. Crashing onto a railway track, it bounced several feet into the air before rolling, unharmed, to rest, and when finally installed it operated perfectly.

Properties of Ferrous Casting Materials

See abstract on p. 75.

S.G. Iron Rolls

H. GOEBEL: 'New Cast Irons for Rolls: Their Properties and Potential Applications.'
Stahl und Eisen, 1957, vol. 77, Feb. 7, pp. 143–157.

In this comprehensive paper the author emphasizes the severity of the demands made on rolls by new rolling-mill techniques, in particular by continuous mills. The conditions are then considered with special reference to the suitability of new roll materials, such as indefinite-chill cast iron and S.G. iron.

After reviewing the various new types of cast iron rolls, their properties, structure, etc., actual operating experience is recorded, with particular reference to the various applications in which the new types of roll can be used with advantage. The author's own experience is summarized in a detailed table which gives histories of some twenty-nine cases in which new types of roll have replaced conventional types. Although in a few cases premature failure has been recorded, the reasons for these failures are known: in other cases a large improvement in output is recorded as a result of the change. Among the positions in which S.G. iron is shown to advantage are section rolls for round billets, slabbing rolls, breaking-down rolls and scale-breaker rolls for certain types of slabs and sections. Hard S.G. iron rolls have been used successfully for polishing steel rod.

S.G. Iron Crankshafts

W. PEPPLER: 'Advantages of Cast Parts.'
Foundry Trade Jnl., 1957, vol. 102, Feb. 14, p. 203.

In an opening address to the Symposium on 'Design and Casting', at the International Foundry Congress held in Düsseldorf in September, 1956, the author briefly reviewed the historical development of castings and considered the relative advantages, under present conditions, of casting as compared with other processes of manufacture. In connexion with 'massive parts', the suitability and economics of castings in various materials are considered in comparison with forgings and a detailed analysis is made of the relative advantages and costs of forged steel and S.G. iron castings for crankshafts. It is pointed out that in addition to very considerable economic advantages accruing from the use of S.G. iron, this material has technical superiority from the point of view of crankshafts, e.g., a yield point higher than that of forged steel, good elongation and superior damping capacity. Further, the cast crankshaft offers the possibility of better design.

'Ductile Cast Iron Crankshafts Designed for Marine Engines.'
Nickel Topics, 1957, vol. 10, No. 1, p. 3.

Considerable economies in production have resulted from the replacement of forged steel by S.G. iron castings for crankshafts in small marine engines. The shafts are heat-treated to a Brinell hardness of 230–270.

S.G. Iron in Machine Tools

'Ductile Iron Parts for Roll Lathe.'
Nickel Topics, 1956, vol. 9, No. 11, p. 2.

The Youngstown Foundry and Machine Company reports successful experience in the replacement of grey cast iron with S.G. iron for vital parts of heavy roll-turning lathes. Parts made from this material include the main headstock casing, the faceplate, the tool carriage and the tailstock. S.G. iron has

been chosen to provide a combination of strength, toughness and wear-resistance and, in addition, has made possible considerable economy in machining. A further advantage is that the high modulus of elasticity and ample damping capacity of this iron provide extra rigidity. For the carriage and faceplate castings the S.G. iron is annealed, while the tailstock and headstock bodies are in the as-cast condition, stress-relieved at 620°C.

S.G. Iron in Road Engineering

'New Highway Saves Maintenance Costs for Drain Grates.'

Nickel Topics, 1956, vol. 9, No. 8, pp. 1, 5.

In the new Massachusetts Turnpike highway, S.G. iron is being used for the grates and frames of the drainage system. This material has been chosen to ensure long life and low maintenance costs, by resisting breakage under shock loading and giving good resistance to corrosion in atmospheric conditions. In all, some 5,000 grates and frames have been cast for this project. The material is being used in the annealed condition.

CONSTRUCTIONAL STEELS

Influence of Retained Austenite on Mechanical Properties

A. P. GULYAEV and I. I. SLAVINA: 'Influence of Residual Austenite, obtained during Quenching, on Impact Strength and Fracture in a Tempered Chromium-Nickel-Molybdenum Steel.'

Metalloved. i. Obrabotka Metallov, 1956, No. 3, pp. 15–17.

Chemical Abstracts 1957, vol. 51, Jan. 25, pp. 989–90.

Report of observations made on a steel containing carbon 0·26, nickel 3·9, chromium 1·3, molybdenum 0·29, per cent., austenitized at temperatures within the range 800°–1000°C. and quenched in water, oil, or air.

High-Speed Machining of Nickel-Alloy Steels

F. A. MENELAUS and B. FRASER: 'Gun-Reaming: New Technique for High-Speed Machining.'

Aircraft Production, 1957, vol. 19, Mar., pp. 100–5.

A requirement which frequently arises in the aircraft industry is that of producing, in high-tensile and stainless steels, holes to extremely exacting standards of size, ovality and finish. The problems involved in this type of machining have been studied in detail in the works of Messrs. Short Brothers and Harland Limited, and a solution has been found in the revival of an old-fashioned gun-drill and its novel application as a high-speed reamer. The development of this process and its use on high-tensile nickel-alloy steels and nickel-chromium stainless steels are described in this well-illustrated article. The advantages of the process, both technical and economic, are discussed, with supporting data based on large-scale industrial experience.

Nickel-Alloy Steel for Aircraft

MINISTRY OF SUPPLY: '80-Ton Nickel-Chromium-Molybdenum-Vanadium Steel.' (Limiting ruling section 6-in.).

D.T.D. Specification 5042, Nov., 1956.

The specification covers (*a*) bars and billets for forging, (*b*) black and bright bars for machining, (*c*) forgings other than crank and propeller shafts, and (*d*) heat-treated parts.

The steel is of the following type:

	Minimum %	Maximum %
Carbon	0·38	0·46
Silicon	0·1	0·35
Manganese ..	0·40	0·65
Nickel	1·5	2·0
Chromium	1·0	1·5
Molybdenum ..	0·8	1·2
Vanadium	0·1	0·3
Sulphur	—	0·045
Phosphorus ..	—	0·045

Heat-treatment comprises hardening in air or oil from a temperature between 900° and 930°C., followed by tempering at a suitable temperature between 550° and 650°C. and cooling in still air. Mechanical properties and Brinell hardness are also specified.

Properties of Ferrous Casting Materials

See abstract on p. 75.

British and German Engineering Steels

W. B. KEMMISH: 'German Engineering Steels and their British Equivalents.'

Machinery (Lond.), 1957, vol. 90, Jan. 11, pp. 84–9.

Comparison, on the basis of composition and of tensile strength, of engineering steels standardized by Deutscher Normenausschuss and some British En steels. Low-nickel alloy steels are included in the survey. The basis of the D.I.N. system of classification is indicated and some general characteristics of German standard steels of heat-treatable and carburizing types are discussed.

Scaling of Nickel Steels

See abstract on p. 78.

HEAT- AND CORROSION-RESISTING MATERIALS

Iron-Chromium-Molybdenum-Nickel Alloys: Constitution

C. J. BECHTOLDT and H. C. VACHER: 'Phase-Diagram Study of Alloys in the Iron-Chromium-Molybdenum-Nickel System.'

Jnl. of Research, Nat. Bur. Standards, 1957, vol. 58, Jan., pp. 7-19; R.P. 2728.

The work described in this comprehensive paper covered iron-chromium-molybdenum-nickel alloys containing 70 and 80 per cent. of iron, with the balance comprising the other three elements in various proportions. The specimens, prepared by powder metallurgy, were examined after quenching from 2200°, 2000°, 1800°, 1650° and 1500°F. (1215°, 1095°, 982°, 898 and 815°C.). Compositional limits of stability of seven phases observed in the alloys are summarized in diagrams.

Incoloy 'T': Data Sheet

INTERNATIONAL NICKEL CO., INC.: 'Incoloy "T": Titanium-containing Nickel-Iron-Chromium Alloy.' Published by *International Nickel Co., Inc.*, 1957; 4 pp.

Incoloy 'T' is an alloy modified from the original Incoloy composition by the addition of about 1 per cent. of titanium, to secure improved tensile and rupture properties. The alloy has excellent oxidation-resistance up to 1600°-1700°F. (870°-925°C.). The chemical composition is as follows:

	%
Carbon	0·10 max.
Manganese	1·50 max.
Silicon	1·00 max.
Chromium	19·0-22·0
Nickel+Cobalt	30·0-34·0
Cobalt (if determined)	1·0 max.
Copper	0·50 max.
Sulphur	0·03 max.
Titanium	0·75-1·50
Iron	Balance

This publication gives physical constants (density, coefficient of thermal expansion over various temperature ranges, and modulus of elasticity), also tensile properties and 100-hour rupture life at various temperatures.

Cracking of Austenitic Steels on Heating

F. A. HODIERNE: 'A Note on the Furnace Cracking of an Austenitic Stainless Steel.'

Jnl. Iron and Steel Inst., 1957, vol. 185, Feb., pp. 225-7.

Cold-drawn tubes, 5½ in. outside diameter by ⅝ in. thick, made from 18-10 chromium-nickel stainless steel containing niobium were found to crack transversely when heated for interpass softening. Such cracking, which can be reproduced experimentally in a laboratory test, at temperatures between 650°-950°C., appears to be associated with the precipitation of intergranular carbides while the steel is under stress. The carbide either increases the local stresses at the grain boundaries or lowers the cohesive strength. Cracking at furnace temperatures of 1050°-1100°C. is attributed to the fact that the steel must pass through the carbide-precipitation temperature range during heating. With thick tubes, the heating is necessarily slow and the time at which the tubes must be maintained in that range may be sufficient for cracking to occur.

On the basis of this possible explanation, a remedial procedure has been devised. All large tubes made in this type of steel are heated at 850°C. for one hour before each cold-drawing operation: this treatment follows the usual interpass softening at 1050°-1100°C. This procedure has been found entirely successful over a period of two years.

It is noted that no cracking of a similar character has been observed in production of tubes in other steels, and that even with the 18-10-Nb steel the conditions causing cracking occur only with one particular size-range of tubes. Laboratory tests indicate that a similar effect is possible in titanium-stabilized austenitic steel.

Scaling of Nickel Steels

K. SACHS: 'Variations in the Structure across the Thickness of the Scale on Nickel Steels.'

Jnl. Iron and Steel Inst., 1957, vol. 185, Mar., pp. 348-57.

Scaling characteristics were studied in three low-alloy nickel steels, under varying conditions. It was found that both the amount of metal in the scale and the overall nickel content passed through a maximum at some distance from the metal core. The scale near the core consists of Wüstite and metal enriched in nickel; the latter has a body-centred-cubic structure (α) near the scale/metal interface and a face-centred-cubic structure (γ) nearer the surface. In the area in which Wüstite predominates all the nickel is found in the metallic particles. At some distance from the scale/metal interface magnetite appears and gradually replaces the Wüstite. At the outer surface of the scale ferric oxide may be found.

The author presents a tentative diagram showing the phases which co-exist at 1200°C. at various nickel contents and partial pressures of oxygen. The diagram is based on somewhat arbitrary estimates, but it incorporates approximate experimental values for the nickel content of metal particles at various points in the scale.

Properties of Electrodeposited Nickel-Alloy Coatings at High Temperatures

W. H. SAFRANEK and G. R. SCHAER: 'Properties of Electrodeposits at Elevated Temperatures.'

43rd Ann. Technical Proceedings, Amer. Electroplaters' Soc., 1956, pp. 105-17.

Information available on the properties of electroplated coatings at elevated temperatures is at present inadequate for assessment of their potential usefulness as protective media, e.g., for molybdenum.

The work described in this report was undertaken, at the Battelle Memorial Institute on behalf of the U.S. Bureau of Aeronautics, to investigate this aspect. Electroplated coatings of the types shown below were subjected to oxidation tests in air and in molybdenum oxide, and also to stress-rupture, thermal-expansion, thermal-stability, ductility and hot-hardness tests.

Coatings Tested

Chromium plating, of conventional and low-contraction types.

Nickel plating deposited from (1) Watts-type solutions and (2) sulphamate solutions.

Gold plating, deposited from a cyanide/tartrate solution.

Chromium-iron alloy plating.

Cobalt-tungsten alloy plating.

Diffusion-alloy plating of nickel and chromium produced by deposition of alternate layers of nickel (from sulphamate solution) and chromium (from low-contraction solution) and subsequent heating for 4 hours at 1800°F. (980°C.).

Results obtained on these coatings were correlated with data available from other sources on the high-temperature characteristics of cobalt, nickel-chromium alloys containing small amounts of aluminium, and platinum.

The respective series of tests are reported in detail, particular attention being given to the possibility of producing coatings which will give protection to molybdenum. Among the major conclusions drawn from an all-over consideration of the behaviour of the respective materials is the usefulness of diffused nickel/chromium coatings. Such coatings have much better resistance to air oxidation at elevated temperatures than is shown by coatings of nickel or chromium alone, but the warning is given that in selecting protective coatings for elevated-temperature service consideration must be given not only to surface oxidation, but also to the rates of intergranular corrosion. Sub-surface oxidation can severely shorten the life of a coating, e.g., with the nickel/chromium diffusion alloy oxidation penetrated intergranularly about five times as fast as it occurred on the surface.

The conditions in which the plating is deposited affect the density and thermal stability of the coatings, which in turn influence the performance of the electrodeposited coating at elevated temperatures.

In application of coatings for protecting molybdenum, it is necessary to find some means of inhibiting the diffusion of molybdenum at elevated temperatures through the nickel/chromium diffusion alloy coating, or other nickel-rich alloy. The authors propose the use of an electrodeposited layer of gold as a barrier. Results suggest that plating with chromium, followed by a layer of gold, and subsequently by alternate nickel and chromium layers, subsequently diffused by heating, offers the best prospect for protection of molybdenum by means of coatings.

Corrosion Products Formed on Metals and Alloys

NAT. ASSOCN. CORROSION ENGINEERS: 'Bibliographies of Corrosion Products.'
N.A.C.E. Publn. 57-5.
Corrosion, 1957, vol. 13, Feb., pp. 111t-21t.

The *bibliography*, which is issued under the aegis of N.A.C.E. Technical Unit Committee T-3B on Corrosion Products, comprises selected abstracts of key literature on the identification and composition of corrosion products on stainless steels (43), zinc (13), zirconium (7), titanium (8), and iron and steel (130).

(The numerals after the names of the materials indicate the number of abstracts in the sections. The iron and steel section is supplemented by an author index.)

Nickel-Chromium-Iron Alloy Belts in Copper-Brazing Furnaces

F. L. HOOPER: 'Service Life of Metal Belts in Copper-Brazing Furnaces.'
Metal Progress, 1957, vol. 71, Feb., pp. 83-5.

Tests on belt sections of various alloys in a copper-brazing furnace showed that 25-20 chromium-nickel steel containing 2·4 per cent. silicon offered better resistance to oxidation than steel of the same type containing only 1·4 per cent. of silicon, and that the lives of belts made from 35-19 nickel-chromium-iron or 80-20 nickel-chromium alloys were 55 per cent. longer than those of belts made from austenitic steels. Further investigation, concerned with the influence of operating conditions, indicated that, given suitable alloy composition and design, the life of belts may be lengthened by decreasing the tension of the belt, increasing the belt speed, and periodic reversal of the direction of the belt.

Structure and Properties of Chromium-Manganese-Nickel Steels

H. KRAINER: 'Structure, Hardness, Notch Toughness and Magnetic Saturation of Heat-Resisting Chromium-Manganese Steels containing 2-6 per cent. of Nickel.'
Archiv f.d. Eisenhüttenwesen, 1957, vol. 28, Jan., pp. 81-9.

The author opens with a general review of some of the limitations of chromium-manganese steels, based mainly on experience in Germany and elsewhere during periods when nickel was in short supply. This is followed by reference to some records of improved properties obtained in chromium-manganese steels containing small amounts of nickel, which indicated the possibility of securing useful characteristics in steels containing more substantial proportions of that metal.

The experimental work reported comprised an extensive investigation of steels containing chromium 10-30, manganese 3-25, per cent., with nickel at the levels of 2, 4 and 6, per cent. Within those limits some 120 varying compositions were tested. Forged

specimens were examined in the conditions produced by the following treatments:

(1) Water-quenching from 1200°C.
(2) Water-quenching from 1200°C., followed by tempering for 1000 hours at 650°C.
(3) Water-quenching from 1200°C., followed by tempering for 100 hours at 800°C.

} Air-cooling

The tests consisted in structural examination by microscopical and X-ray methods, determinations of Brinell hardness, and measurement of magnetic saturation. It is shown that manganese favours formation of sigma phase but that nickel has a suppressing effect. In nickel-free chromium-manganese steels sigma phase appears at chromium contents of 13 per cent. and upwards, but addition of 6 per cent. of nickel raises to about 18 per cent. the lower limit of chromium at which the phase is formed. Steels containing chromium 18, manganese 5-8, nickel 6 per cent. maintain a stably austenitic structure and do not become embrittled even on prolonged heating. In steels of a mixed austenite-ferrite structure sigma phase forms from the ferrite, but there are indications that there is simultaneously some concentration change in the austenite, and it is possible for sigma to form from austenite in ferrite-free steels.

Acid-Resisting Nickel-based Alloys

'The Rôle of Special Nickel-based Alloys in the Chemical Industry.'

Chemical and Process Engineering, 1957, vol. 38, Mar., pp. 95-7.

The article describes the properties of the series of Langalloy alloys developed for handling acid solutions of varying types and concentrations. Nominal compositions are shown in the table below: details of the mechanical properties of the alloys, as sand castings, are given in the original.

The corrosion-resisting characteristics of the materials are reviewed, and notes are added on the suitability of the respective types for handling sulphuric, hydrochloric, nitric and phosphoric acids in various concentrations and at various temperatures.

Stainless Steels for Pressure Vessels

A. GRODNER: 'Stainless Steel for Pressure Vessels.'

Welding Research Council Bull. No. 31, Nov. 1956; 20 pp.

Stainless steels of various types are being increasingly used in pressure-vessel construction, to meet the severe demands of modern processing industries. The specific advantages resulting from the use of such materials are

(*a*) Increased corrosion-resistance.
(*b*) Elimination or reduction of contamination of the product handled.
(*c*) Higher strength, particularly at elevated temperatures (austenitic steels).
(*d*) Improved resistance to scaling.
(*e*) Higher toughness, with better impact-resistance at very low temperatures (obtained with the austenitic steels).
(*f*) Reduced maintenance costs.

Sixteen of the thirty-five wrought stainless steels standardized in the U.S.A. and five of the twenty-eight cast types are recognized by the A.S.M.E. Boiler and Pressure Vessel Code as providing the varying degrees of heat- and corrosion-resistance and the combinations of mechanical properties required in vessels operating under varying conditions from close to absolute zero to above 1500°F. (815°C.).

The aim of the summarized information presented in this report is to provide authoritative practical data which will enable users to select the grades of steel best suited for individual requirements, and to determine the condition in which the materials must be used in specific applications. The subject is covered in the following classifications:

Grades of Stainless Steel

Tables showing compositions of the standard grades of wrought (A.I.S.I.) and cast (A.C.I.) steels recognized by the A.S.M.E. Boiler and Pressure Vessel Code, with information on U.S. specifications covering the respective materials.

	Langalloy 4R %	Langalloy 5R %	Langalloy 6R %	Langalloy 7R %
Nickel	63	56	85	57
Copper	—	—	3	6
Iron	5	5	—	6
Manganese	0·75	0·75	—	—
Chromium	—	15	—	23
Molybdenum	30	17	—	6
Tungsten	—	5	—	2
Silicon	0·75	0·75	10	—

Mechanical Properties of the Steels at Normal, Elevated and Sub-Atmospheric Temperatures.

Corrosion-Resisting Characteristics of High-Chromium and Nickel-Chromium Steels.

Scaling-Resistance and Resistance to Corrosion at Elevated Temperatures.

Embrittlement Phenomena in Stainless Steels.

475°C. embrittlement of chromium steels; embrittlement due to carbide precipitation; embrittling influence of sigma and chi phases.

Design Factors

Stress values permissible according to the A.S.M.E. Boiler and Pressure Vessel Code; designing for special service conditions; the responsibility of the fabricator in maintaining the materials in the condition best suited for the service for which they are intended.

Fabrication

Notes on the workability of the various grades of stainless steel, with recommendations on methods suitable for cutting, forming, welding and machining.

Inspection and Testing Procedures

Radiographic methods, fluid-penetrant test, impact test, weld test plates, and the copper-sulphate test for determination of susceptibility to intergranular corrosion.

Precipitation-Hardening Stainless Steel for Fasteners

'Redesign Adapts Part for Higher-Heat Service.'

Iron Age, 1957, vol. 179, Feb. 21, p. 99.

This note records a typical example of modification in materials, to meet changed operating conditions involving elevated temperatures. The requirement was that a latch fastener which had been used on engine cowls in piston engines should be adapted for jet engines. The same design of latch could be used, but it was necessary that the one at the exit end should be made in a material which would be capable of operating at 500°–900°F. (260°–480°C.).

The solution to the problem was found in the use of cast precipitation-hardening 17-4 P.H. steel for the body and of 17-4 and 17-7 P.H. steels for the springs.

Stainless-Steel Lock Washers

SOC. AUTOMOTIVE ENGINEERS: 'Lockwashers, Steel, Corrosion-Resistant.'

A.M.S. Specification 7241, Jan. 15, 1957.

The specification covers lockwashers primarily intended for use with corrosion-resisting steel threaded fasteners, at temperatures not above 700°F. (370°C.).

Composition limits are as follows:

	%
Carbon	0·15 max.
Silicon	1·00 „
Manganese	2·00 „
Sulphur	0·030 „
Phosphorus	0·045 „
Nickel	9·00-10·00
Chromium	17·00-19·00

The material is to be supplied in the cold-worked condition, having a hardness of Rockwell C 35–43 or equivalent. The specification also includes requirements relating to coiling, temper, and toughness of the washers.

Resistance of Nickel Alloys to Tanning Solutions

R. STRATTA, G. B. FERRARIS and M. T. GONELLA: 'The Corrosion of Metals in Tanning Solutions.'

Cuoio, Pelli, Materie Concianti, 1956, vol. 32, pp. 163–70.

Report of tests on metals and alloys in solutions of tanning extracts and synthetic tannins, over the range 18°–120°C. The materials giving best resistance to corrosion were Hastelloy C (nickel-molybdenum-chromium-iron alloy), 18–8 chromium-nickel steel and silver.

Nickel-Plated Fourdrinier Wires

E. H. SHRIVER, G. B. KING and A. G. HOSE: 'Increased Life from Nickel- and Tin-Covered Fourdrinier Wires.'

TAPPI, 1956, vol. 39, Sept., pp. 618–25.

The paper consists of the case history of a corrosion problem occurring in a paper mill using the neutral sulphite process to cook Appalachian hardwoods, for conversion into a corrugating material. The warp wires of the cloth used in the Fourdriniers was normally of phosphor bronze and the shute wires were of brass. The writers give reference to literature on the corrosion difficulties which have been experienced with wire cloth of this type, and describe in detail a systematic study of the problem. The report includes extensive data on the effect of variables in the white water handled, and the effect of corrosion on the mechanical properties of the wire is discussed. Corrective methods considered and tested included treatment of the white water with sodium sulphite, cathodic protection, the addition of several organic corrosion inhibitors, and the use of tin- or nickel-plated wires. Tests to date have indicated that the plating method is promising, and mill tests are now in progress to confirm that increased life can consistently be obtained by this means.

Welded Joints in Austenitic Steel Tubing

R. W. EMERSON and R. W. JACKSON: 'The Plastic Ductility of Austenitic Piping containing Welded Joints at 1200°F.'

Welding Jnl., 1957, vol. 36, Feb., pp. 89S–104S.

Cracking of niobium-stabilized '18–8'-type austenitic steel, particularly in or near welded joints, is a problem of major importance to steam-plant engineers, and the literature already includes numerous reports of investigations of the defect, with some proposals for remedial measures.

Information already available to the present authors had led to the conclusion that premature failures in this material are of a stress-to-rupture type, and that the lack of high-temperature ductility-to-fracture characteristic of that steel, particularly

in a coarse-grained condition, is one of the principal causes for many of the failures in piping adjacent to welded joints.

With this background, simulated-service tests were carried out in an attempt to produce the low-ductility failure which has been observed in large-scale service. A second objective of the tests was to evaluate the influence of the grain size of the basis metal, on fracture ductility as measured by elongation of the specimen. Further, the research was to include the development of a metallurgical treatment which would improve the hot plastic ductility across the welded joint, so providing a greater ability to accept additional plastic strain resulting from high stresses imposed during service. The tests were to be made on both the niobium-stabilized (Type 347) and molybdenum-containing (Type 316) chromium-nickel steels.

A very detailed account is given of the base metals and the electrodes used, also of the effect of heat-treatment on grain size and room-temperature mechanical properties. This is followed by a report of the fabrication procedure used for production of high-temperature specimens and the apparatus and technique used in the high-temperature tests. In that series of experiments, a total of 28 tests was made on specimens comprising as-received, fine- and coarse-grain annealed 347 and 316 steel welded to similar material. Similar materials, dissimilarly heat-treated, were also welded and tested, as were welded joints of dissimilar composition which had undergone both similar and dissimilar heat-treatments. In addition, two tests were made on welds produced with 16-8-2 chromium-nickel-molybdenum steel electrodes, on both types of basis material.

Correlation of the features found during the examination of the laboratory specimens, with phenomena observed in typical examples of service failures, confirms the view that the defect is of a stress-rupture nature. The authors propose a mechanism of failure based on the summation of all stresses acting upon a given area, at a given temperature, for a given time. For a given operating temperature, stress rupture will occur with lessening time as a function of increased stress applied. Localized areas of high stress (irrespective of the origin of the stress) will fail prematurely if the material has no capacity to absorb this stress by plastic deformation.

Among the general conclusions drawn from these tests are the following:

Increasing the solution-treating temperature and thus enlarging the grain size resulted, in both steels, in a general lowering of the room-temperature tensile strength, yield strength and Brinell hardness, and in an increase in percentage elongation and reduction of area.

Deterioration in room-temperature ductility was observed in the Type 347 steel heated at 2300°F. (1265°C.), by comparison with that found in the same steel heated at 2100°F. (1150°C.). This loss in ductility was not observed in the Type 316 steel, which leads to the conclusion that the 347 Type may be more susceptible than Type 316 to structural damage when subjected to high temperatures such as those involved in welding.

Tack welds and arc-strikes which give rise to microfissuring (metallurgical notches) and sharp changes in cross section (mechanical notches) giving rise to stress concentration may readily lead to premature stress-rupture failures in austenitic steels, particularly those of Type 347.

The report includes much information on the influence of solution-treatment temperature and on the effect of post-weld heat-treatment.

Prevention of Stress Corrosion in Stainless-Steel Equipment

C. EDELEANU: 'Avoidance of Stress Corrosion in Austenitic Steel Equipment.'
Corrosion Technology, 1957, vol. 4, Feb., pp. 49–52.

After some general consideration of the nature of stress corrosion, the writer of this article reviews the current stage of knowledge of the problem and discusses stress-corrosion failure in plant handling chloride or caustic solutions, or in contact with water and/or steam.

High-Speed Machining of Nickel-Alloy Steels

See abstract on p. 77.

Attention is drawn to the fact that many of the names of materials mentioned in The Nickel Bulletin are *Registered Trade Marks*.

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